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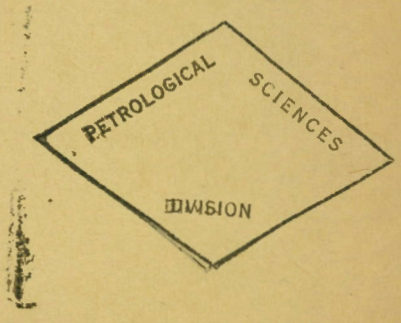
SEISMIC SURVEYS and THEIR RELATION to OIL PROSPECTS in WAINWRIGHT AREA, ALBERTA

BY

G.S. Hume

Geologist for Oil Controller



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SEISMIC SURVEYS AND THEIR RELATION TO OIL PROSPECTS IN WAINWRIGHT AREA, ALBERTA

INTRODUCTION

During the summer of 1943 a seismograph survey of an area in Buffalo National Park, Wainwright, Alberta, and of an area in the vicinity of nearby producing oil wells was carried out by Heiland Exploration Company, under the direction of Mr. A.E. Brayton, for the Oil Controller for Canada and the Department of Mines and Resources, Ottawa. Three and a half months were spent on this work, and the seismic maps accompanying this report were prepared. Mr. George Shaw of the Geological Survey co-operated with the seismic party. Wainwright is 140 miles east of Edmonton on the main line of the Canadian National Railways.

Buffalo National Park is no longer used for park purposes, but is a military camp that is available for oil and gas development under special arrangements. The area to the north of Wainwright, however, has several producing oil wells, and the seismic survey in this area was undertaken in the hope that the study of the relationships between oil production and subsurface conditions, as revealed by the seismograph, might lead to conclusions justifying further drilling and expansion of oil production in this area. It is now possible to make certain deductions in regard to the more favourable areas for the location of new wells, although the relationships between oil accumulation and subsurface conditions are not as evident as it was supposed would be the case.

HISTORY OF THE WAINWRIGHT OIL FIELD

Drilling was first undertaken in Wainwright area at British Petroleums No. 1 well, in 1922. Previously there had been drilling, with oil and gas indications, in the Fabyan area, 8 miles to the west where, in 1929, the gas wells that now supply the town of Wainwright were completed. There seems to have been no reason for the location of British Petroleums No. 1 well other than that it is on a pronounced bend of Battle River Valley, but the driller, the late David Credille, had come to Canada from Burkburnett, Texas, and had the idea that the river bends to some extent reflected the structure of the bedrock. The first well, however, was not a commercial success, but sufficient oil was present to lead to further drilling over a considerable area. A few wells were drilled prior to 1930, and these have yielded a small daily production for many years. With the exception of one well, Wainwright Development No. 1, drilled in 1942, there has been very little drilling since 1930. Two areas of promise were discovered. The first of these centred in the area 4 miles north of town and the other $\frac{1}{4}$ mile northwest of town in the area where the Gold Standard refinery is now located. The first of these is the only one producing oil at present, although a small amount of gas for refinery use is still obtained from two of the wells in the other area.

GEOLOGY

The geology of Wainwright area has been described in detail in Geological Survey reports[1].

1

Hume, G.S., and Hage, C.O.: "The Geology of East-Central Alberta"; Geol. Surv., Canada, Mem. 232, 1941.

Hume, G.S.: "Oil and Gas in Western Canada"; Geol. Surv., Canada, Ec. Geol. Ser. No. 5, 1933.

Except along Battle River Valley, which is 300 feet deep in the area north of Wainwright, the bedrock is largely concealed by glacial drift. In the Park area to the southwest of the town, the surface is largely covered by sand hills. In drilling seismic shot holes, a former tributary of Battle River was discovered in which a depth of 200 feet of sand was drilled without completely penetrating it. This is a preglacial or interglacial valley that was filled by glacial materials such as are now found in the valley of Battle River itself.

The succession of geological formations beneath the glacial drift is as follows:

Age	Formation	Thickness	Description
Upper Cretaceous	Pale and Variegated beds	About 970 feet near Czar, but upper part eroded in Wainwright area.	Sandstones and bentonitic shales with coal seams. Mostly non-marine, but with marine shales in the lower part of the Variegated beds.
	Birch Lake	About 100 feet. Well exposed along upper part of Battle River Valley north of Wainwright.	Massive sandstone at top and bottom of the formation with shales and sandy shales in the middle part. Oyster bed at base in certain localities.
	Grizzly Bear	100 to 110 feet. Exposed near the mouth of Grizzly Bear Coulée.	Marine shales with interbedded sands. Coal seam and carbonaceous shales at the base at the mouth of Grizzly Bear Coulée.
	Ribstone Creek	180 to 200 feet. Upper part exposed in the lower part of Battle River Valley. Lower part exposed near the mouth of Ribstone Creek near the Saskatchewan boundary.	Sandstone prominent in upper and lower part with a coal seam in Battle River Valley, northeast of Wainwright. Central part largely shales.
	Lea Park	650 to 700 feet. Exposed on Vermilion and Saskatchewan Rivers at Lea Park.	Light grey marine shales, sandy in upper part.
	Alberta	800 to 840 feet. Total thickness of Lea Park and Alberta shale is approximately 1500 feet. Known only from boreholes in Wainwright area.	Dark marine shales, sandy at Viking gas sand horizon about 130 to 140 feet above the base. Pebbles may occur in the Viking sandy zone and in the shales immediately overlying the Lower Cretaceous. A marked pelecypod shell zone occurs a few feet above the Lower Cretaceous contact.

Age	Formation	Thickness	Description
Lower Cretaceous		Variable thickness according to irregularities of underlying erosional Devonian surface. 250 to 325 feet.	Sandstone and shales, in part highly bentonitic. Thin coal seams. Also dark marine shales containing foraminifera.
Devonian		Thickness unknown, as no exposures on Alberta plains south of McMurray on Athabaska River. At least several hundred feet thick. Good porosity, at least locally.	Limestones and dolomites. Some variegated red and green shales may or may not be present at the top.

PRODUCING OIL AND GAS HORIZONS

Viking Sand Equivalents

The sand that produces natural gas in the Viking and Kinsella areas west of Wainwright is in the Alberta shales about 130 to 140 feet above the top of the Lower Cretaceous. The sand where drilled has been free of water and the gas is produced in volumes apparently more in direct relationship to the porosity than to the local structure. The regional dip of the formations is to the southwest, and up the dip toward Wainwright area the sand becomes replaced by sandy shales. At Fabyan, 8 miles west of Wainwright, two Maple Leaf wells have supplied gas for the town of Wainwright for many years. The initial volume of gas from each of these wells was 1,500,000 to 2,000,000 cubic feet a day at a closed pressure of 750 pounds. The Fabyan area, however, seems to be the approximate eastern limit of production and it may be that in the Wainwright field the producing sands of the more westerly area are largely replaced by relatively impervious sandy shales. Shows of gas, however, are present at this horizon, which can be recognized in the electrolog of a well drilled recently north of Wainwright. Aside from a small production of gas, therefore, the Viking sand horizon is not expected to have any value in Wainwright area.

Upper Sand of the Lower Cretaceous

In most wells, but not all, the top of the Lower Cretaceous is a sand. Gas and oil have been encountered in this over a wide area, but in every known case, regardless of structure, the base of the sand is said to have carried salt water. Gas occurs in the sand in the Viking gas field, but production from it has never been satisfactory and in all recently drilled wells in that area, it is not tested. In the Fabyan area a large flow of gas is reported to have been encountered in this sand in Imperial Fabyan No. 1 well, l.s. 16, sec. 18, tp. 45, rge. 7, at a depth of 1,870 feet. Water occurred with the gas and the well was never produced satisfactorily, although some heavy oil occurred in deeper sands. In British Petroleums No. 4 well, drilled in 1924 in l.s. 13, sec. 30, tp. 45, rge. 6, about 5 miles north of Wainwright and not far from the discovery British Petroleums No. 1 well, oil flowed from the 8-inch casing from this sand at a depth of 2,025 to 2,036 feet, but again the well was never produced satisfactorily. Oil has been noted in this sand in many of the wells drilled at Vermilion, where cores of the top of the Lower Cretaceous are commonly taken, and, in the Lloydminster area, Shaw No. 2 well, l.s. 10, sec. 25, tp. 49, rge. 1, has produced some oil from

this sand at a depth of 1,755 to 1,760 feet, but in this as in other places the oil is emulsified by mixture with water. What is believed to be the best flow of oil from this sand in Wainwright area occurred in Wainwell No. 1 well, l.s. 9, sec. 36, tp. 44, rge. 7, about ¼ mile northwest of town and close to the Canadian National Railway. This well was reported to have had an initial flow of as much as 300 barrels a day from a depth of 2,068 to 2,072 feet, but again the well was never produced satisfactorily. In the same area Wainwell No. 2 well, l.s. 15, sec. 36, tp. 44, rge. 7, had an initial flow of gas measured at 33,000 M cubic feet a day, but the flow rapidly decreased after the well had been shut in. The reason for the decrease is unknown, but it might have been due to causes other than exhaustion.

These widespread occurrences of oil and gas in the upper sand of the Lower Cretaceous are evidences that this sand could be a prolific source of oil under favourable conditions. This not only applies to Wainwright area, but to the entire Wainwright-Vermilion-Lloydminster district. In places the sand is known to be 20 feet thick and may be composed of relatively coarse quartz sand grains, but there is a wide variation in different areas both in thickness and character. In the only well recently drilled in Wainwright area, Wainwright Development No. 1, l.s. 8, sec. 17, tp. 45, rge. 6 (elevation of well from Kelly bushing at 2,308 feet), where both a core and an electrolog were taken, the core recovery at the top of the Lower Cretaceous was very poor, and although an oil show was present, the only part of the sand recovered was rather hard. The log for this part of this well is as follows:

Alberta shale

Coring started at a depth of 2,050 feet

2,050 - 2,080 feet	Dark grey shale
2,080 - 2,090 "	Dark grey shale, 4-inch sand at 2,087 and abundant fossil shells at 2,088.5 feet.

Lower Cretaceous

2,090 - 2,100 feet	Poor core recovery. Contact between Alberta shale and Lower Cretaceous may be about 2,092 feet. An oil show occurred in rather firm sandstone.
2,100 - 2,110 feet	2 feet grey and brown sand. 7 feet firm sandstone with oil and gas. 1 foot hard grey sandstone.

The electrolog shows oil content from 2,092 to 2,108 feet, with a possible thin water sand at 2,098 feet. A drill stem test at 2,100 to 2,103 was negative. Water rose 750 feet in drill stem.

Wainwright Sand

The main production in Wainwright area has been secured from a sand 120 to 140 feet below the top of the Lower Cretaceous. In a few wells the depth seems to be slightly greater, but in many of the early drilled wells at Wainwright, the information is relatively inaccurate. In the Sasko-Wainwright well, which, since its completion in 1929 up to the end of September 1943, has yielded 48,493 barrels of oil, the sand is reported to have been in two parts, at depths of 2,225 to 2,236 feet and from 2,239 to 2,247 feet. In most of the other wells, however, only one sand was reported, ranging in thickness from a few feet to possibly 10 feet or more in a few wells. The oil sand is relatively soft, fine-grained, and heavily saturated. In one well, National Exploration,

l.s. 1, sec. 30, tp. 45, rge. 6, close to producing oil wells, the sand carried a heavy flow of gas reported at 14,000 M cubic feet a day. The well was never produced, as there has been no market for the gas.

Above the Wainwright oil sand the Lower Cretaceous consists of sandstones with bentonitic and carbonaceous shales. One prominent carbonaceous zone with coal seams, probably not very thick, is encountered in wells in the Wainwright field about 30 feet above the oil sand. The carbonaceous zone may be as much as 15 feet thick. Other less prominent carbonaceous shales are present at various depths. It is assumed that part of the Lower Cretaceous in Wainwright area is marine in origin, as marine foraminifera have been identified from Lower Cretaceous[1] in other wells drilled in this general area.

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1 Hume, G.S., and Hage, C.O.: Geol. Surv., Canada, Mem. 232, p. 12.

Devonian Prospective Oil Horizons

The Devonian, consisting mainly of dolomites and limestones with a minor amount of shale, underlies Lower Cretaceous strata from which it is separated by an erosional disconformity. In many wells drilled in Wainwright area, mottled green and red shales occur immediately below the contact, but in other wells these are absent and Lower Cretaceous sediments rest on Devonian dolomites and limestones. In some of the wells drilled in east-central Alberta, a feature of the Devonian has been the high degree of porosity present through a considerable thickness of beds. This thickness is variable, but may be as much as 600 feet, as in Anglo-Home Buffalo Coulée No. 1 well, l.s. 16, sec. 26, tp. 47, rge. 7, W. 4th mer., where the porous beds constituted a very considerable part of the section penetrated. The porosity appeared to be closely associated with dolomites. Limestones were generally more compact and tight, although crystalline beds showed porosity. In some instances, the pores are small vugs up to $\frac{1}{4}$ inch in diameter, as in the Pacalta well, l.s. 3, sec. 5, tp. 48, rge. 5, at a depth of 2,370 feet, or 40 feet below the top of the Palaeozoic. The porous zones in the upper part of the Devonian section of a few wells have been oil stained, but up to the present, no production has been secured from these beds in east-central Alberta.

In Wainwright area porosity in the Devonian has not been so marked as it has been in some wells in adjoining areas. In the Admiral well, l.s. 16, sec. 36, tp. 44, rge. 7, the top of the Devonian, encountered at a depth of 2,360 feet, consisted of 30 feet of green and maroon shales underlain by 130 feet of magnesium limestones. Below this the beds are white limestones to a depth of 2,590 feet, where there is a change to darker dolomitic beds to the bottom of the well at 2,698 feet. The only porosity that can be observed in the samples is in the lower 100 feet of dolomitic beds, but this is moderately good. In drilling the well circulation was lost from 2,617 to 2,673 feet. This indicates good porosity.

In the Montreal Alberta well, l.s. 2, sec. 15, tp. 45, rge. 7 (elevation of well 2,211 feet), a Palaeozoic section has been drilled from 2,321 feet to the bottom of the well at 4,647 feet, or a total of 2,326 feet of beds. No information is available as to the exact age of the lower part of these beds, although presumably the upper part is Devonian. In this well, which is only 3 miles from the Admiral, there are no greenish and maroon shales at the top of the Palaeozoic, and Lower Cretaceous strata rest on light grey limestones with a small amount of dark grey shales. The limestones are partly highly crystalline and these beds are porous. The light grey limestones continue to a depth of 2,620 feet, where they become darker and contain a minor amount of dolomite and a considerable amount of calcareous greenish shale to a depth of 2,660 feet. From this depth to 2,685 feet the limestone is crystalline. Water is reported to have occurred at 2,475 feet, rising to 900 feet,

and again at 2,685 feet, rising to 500 feet. From 2,685 to 2,890 feet, the beds are greenish calcareous shales with grey limestones, but mostly the shales predominate. Below 2,890 feet and down to 3,390 feet, the beds are mainly brown limestones with greenish shale bands. In the well an oil show was reported[1] at 3,380 to 3,390 feet, but there is no evidence of this in the samples. No water or oil is known to have occurred below this depth.

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[1] Beach, F.K.: "Schedule of Wells Drilled for Oil and Gas to 1941"; Dept. of Lands and Mines, Edmonton, Alberta.

From these widespread evidences of porosity it seems reasonable to expect that reservoir rocks will be found in the Devonian of Wainwright area, and that these under favourable structural conditions could yield oil.

The attitude of the bedding of the Devonian in the erosional knobs is assumed to be relatively flat, but very little information from cores in Wainwright area is available. It is not possible to correlate such cores as have been obtained; for example, cores from the Admiral well cannot be correlated with samples from the Montreal Alberta well even though these wells are only 3 miles apart. For oil that originated in the Devonian, the conditions for accumulation in the porous beds of the buried knobs would be across the bedding planes or along the erosional unconformity. Presumably oil could also migrate into the Devonian porous beds from the lenticular sands of the Lower Cretaceous, which incline upwards and abut against the Devonian knobs. It would seem possible, therefore, without having actual anticlinal conditions in the Devonian beds themselves, to have the erosional knobs acting as structures for the retention of oil. In regard to the overlying Lower Cretaceous the anticlinal conditions are provided by the deposition around and the settling of these beds over the Devonian erosional masses.

PRODUCTION IN WAINWRIGHT AREA

Twenty-five wells have been drilled in Wainwright area. Five of these are ¼ to ½ mile northwest of town, close to the Canadian National Railway; three are scattered to the north and northwest within 1 to 3 miles of town; and most of the remainder are on a northwest and southeast trend about 3 miles northeast of town. Among the latter group are the only wells that now are productive. The record of production is as follows:

Well	Location	Completed	Production to end of 1942	Production Jan. to Sept. 30, 1943.	Total Production to Sept. 30, 1943.
		Feet	Bbls.	Bbls.	Bbls.
Bethwain No. 2	L.s. 16-4-45-6	1,931 at 2,305	4,536	634	5,170
Edmonton Wainwright	L.s. 4-29-45-6	1,926 at 2,274	33,848	1,793	35,641
(Hargal 3B (British Petroleums (3B	L.s. 4-29-45-6	1,925 at 2,250	33,883	5,169	39,052
Sasko Wainwright	L.s. 1-19-45-6	1,929 at 2,247	46,239	2,254	48,493
Wain-Con. (Onalta)	L.s. 8-20-45-6	1,930 at 2,232	31,774	2,202	33,976
Wain. Development	L.s. 8-17-45-6	1942 at 2,369 Plugged back to 2,236.	1,117	1,030	2,147
Wain. Petroleums	L.s. 6-30-45-6	1,930 at 2,252	8,091	493	8,584
Other wells			11,775		

The grade of oil produced is 18° to 22° A.P.I. Hargal 3B well, after being cleaned, has been producing slightly more than 600 barrels a month for several months.

THE SEISMIC MAP

The reflection seismic method as used in Wainwright area has been described by A.E. Brayton, who was in charge of Heiland geophysical operations in Wainwright area, as follows:

"This method records mechanically by means of a combined electrical and photographic process the travel times of artificially propagated seismic waves, travelling from the surface of the earth to the various strata beneath, which, by reason of their variation of physical properties, produce a change in the velocity of travel of these waves. Any marked variation in the velocity of these waves as they travel through these strata, causes a portion of the wave energy to be reflected back to the surface of the earth from the strata responsible for such variation.

"These artificial seismic waves are produced by an explosion of a charge of dynamite specially manufactured for this work. Charges of varying quantities are exploded in drilled holes at depths which vary from 30 to 300 feet.

"The wave energy reflected from any stratum is picked up by means of sensitive electrical detectors placed at fixed intervals in a straight line on the surface of the earth, and transferred through wire conductors as electrical energy to a mechanical photographic recording apparatus. This final photographic record of the times of travel of these waves from the bottom of the shot holes to the various strata and return, appear in graphic form and comprise what is known as a seismogram. Several of these seismograms are usually recorded at each shot-point. By means of an interrupted beam of light at exact intervals of one-hundredth of one second, vertical lines appear across the seismograms which provide an exact means for the computing of these travel times in terms of one-thousandth of one second. After an adjustment to a common datum plane and other corrections have been applied to these observed times, we have an actual physical measurement in terms of time from the surface of the earth to any strata beneath capable of providing a reflection. When the travel times of the seismic waves which have been reflected from the same horizon are plotted on a map, and contour lines are drawn through points of equal value, a picture of the reflecting horizon is the result.

"Finally by other means, velocities of these travel times are determined and the times are then converted into depth in feet. These depths, when plotted and contoured, form a subsurface structural map of the reflecting horizon in terms of actual depth in feet."

It should be clearly understood that the maps accompanying this report (See Figures 2 and 3) represent the configuration of the probable Devonian erosional surface beneath Lower Cretaceous strata. The maps are based on the velocity determined at the Admiral well, l.s. 16, sec. 36, tp. 44, rge. 7, which reached the top of the Palaeozoic limestone at 2,360 feet. No correction for a slight change in velocity has been made for the record at Wainwright Development well, l.s. 8, sec. 17, tp. 45, rge. 7, which reached the top of the Palaeozoic at 2,330 feet, or 22 feet below sea-level. On the map (Figure 2) the Wainwright Development well location is shown as -01 feet, which is the depth calculated from the assumed velocity as determined at the Admiral well. This slight change in velocity which occurs between the two wells in no way alters the relationship of one shot point to another, and thus does not change the shape of the Devonian surface as depicted by the map, although there is a minor difference in actual and calculated depths at the Wainwright Development well.

The maps show three erosional high areas:

(a) A large area in the northeast corner of Wainwright Buffalo Park with small closure to the northeast made by a poorly defined syncline parallel to the Canadian National Railway and rising again northeast to

(b) A well-defined Devonian knob, the top of which covers approximately 1 square mile about 3 miles northeast of Wainwright station

(c) A very pronounced buried Devonian knob half in the southeast corner of Buffalo National Park and half adjoining the park on the south. This structure is approximately half way between Wainwright and Czar.

For convenience it is proposed to call the erosional high area within the northeast corner of Buffalo National Park and extending into secs. 4 and 5, tp. 45, rge. 7, the "Mott Lake" structure, from Mott Lake in the park, and to name the structure 3 miles northeast of Wainwright the "Aykroyd" structure after the late Richard Aykroyd, a pioneer in the Wainwright country, who owned sec. 17, tp. 45, rge. 6, the south part of which is on the high part of the structure. It is also proposed to call the south structure the "Vale" dome, from the municipality of Vale in which the structure occurs.

In the seismic survey it was hoped to obtain reflections from other horizons than the erosional Devonian surface. In the records, according to Brayton, a reflection was observed that originated from strata believed to be very near the contact between Upper and Lower Cretaceous beds, but the relfection only occurred intermittently and after checking the interval this relfection was found to be conformable with the Devonian surface where it is comparatively flat and diverged from it where the Devonian surface has a sharp inclination. This indicates that the Lower Cretaceous beds are lenticular in part, thinning toward the buried Devonian knobs and thickening away from them in such a way as to form favourable stratigraphic traps on the flanks. This deduction from the seismic records is supported by information from drilled wells. Wainwright Development No. 1 well is on the north flank of the rather prominent erosional Devonian mass, herein called the Aykroyd structure, and in it the Lower Cretaceous strata are 238 feet thick, whereas in the Admiral well drilled in a lower Devonian erosional area they are 306 feet thick. This is a difference of 68 feet in slightly more than 3 miles. As would be expected, however, this difference is less than the difference in elevation of the Devonian surface, which in the case of these two wells amounts to 112 feet. This means that Lower Cretaceous sediments, probably laid down on the erosional surface with a depositional dip, in part at least filled up the low areas before the sediments covered the tops of the Devonian knobs. Such a condition would tend to develop lenticular beds with the thin edges toward or lying against any high area. Thus, there are probably better stratigraphic traps for the accumulation of oil and gas in the lower part of the Lower Cretaceous than in the upper part where the beds are more likely to be continuous over the whole area, as seems to be the case with the productive Wainwright sand, 120 to 140 feet below the top of the Lower Cretaceous. It is probable, however, that the low areas of the erosional floor were not filled uniformly level before the higher parts received some sediments, so that presumably there is not only a slope away from the high areas, due to depositional dip, but this has been increased by greater shrinkage due to compaction in the areas of thicker sediments. It is inferred that this has resulted in a dip in the Lower Cretaceous in all directions away from the buried Devonian knobs. Under such conditions it is apparent that such a structure might show considerable closure within the Lower Cretaceous, whereas the amount would tend to decrease upward in the Upper Cretaceous and show only a slight structure in the surface beds. From the seismic records, as well as such information as is available from the thickness of the Lower Cretaceous, it appears, therefore, that the erosional Devonian knobs have caused structural conditions favourable for oil and gas accumulations in the Lower Cretaceous sediments in which they are buried. Similar structures over buried hills have given prolific oil production in many areas in the United States.

MOTT LAKE STRUCTURE

The Mott Lake structure (See Figure 2) is mostly within the northeast part of the park, but extends into sections 3, 4, and 5 in township 45, range 7, where the highest known part occurs. It was hoped to find a structure within the park suitable for drilling for natural gas for the Wainwright Military Camp, but in this respect the part of the Mott Lake structure in proximity to the camp was not considered sufficiently attractive as the closure of the whole structure to the northeast is small. In this area it is probable that the Viking gas horizon will be represented by only sandy shales from which the yield of gas would be insufficient to justify the drilling costs, and the gas prospects of the Lower Cretaceous are nowhere reliable in the Wainwright area.

In regard to oil prospects the higher northwest part of the Mott Lake structure may have some merit as being sufficiently high to cause the Lower Cretaceous sediments to dip away from it, but drilling on it cannot be recommended unless production on the still better Aykroyd structure is obtained. Only one well has been drilled in the vicinity of the northwest part of the Mott Lake structure. This is Beaumont No. 1 on l.s. 1, sec. 10, tp. 45, rge. 7. This location is in reality close to the bottom of a syncline that is parallel to the Canadian National Railway. In it the top of the Lower Cretaceous was encountered at a depth of 2,035 feet and the Wainwright oil sand at a depth of 2,162 feet. The initial yield of oil was very small and the well has never been produced. From the seismic map it would be expected that the top of the Devonian on the high part of the Mott Lake structure would be approximately 60 feet higher than at the Beaumont No. 1 location. The amount of closure of the Mott Lake structure to the northeast is apparently very small, as the depression in the Devonian surface in the vicinity of Beaumont No. 1 well disappears to the southeast.

AYKROYD STRUCTURE

The Aykroyd structure (See Figure 2) is a pronounced buried Devonian knob that is expected to have given a considerable amount of doming in the Lower Cretaceous strata in its vicinity. Only one well, Wainwright Development No. 1, l.s. 8, sec. 17, tp. 45, rge. 6, has been drilled in proximity to the top of the structure, but even this is some distance down the north flank. If the seismic map indicates approximate conditions, as is believed to be the case, then there are about 1,000 acres of Devonian strata in the structure higher than their level in the well. This is considered important in view of the fact that a slight oil staining occurred in a dolomitic streak in the core taken between 2,335½ and 2,348½ feet. In the core between 2,353½ and 2,369½ feet there was dolomite with many vugs and circulation was lost at 2,369½ feet, indicating considerable porosity. About 640 acres, or 1 square mile, of the Aykroyd structure, as shown by the seismic map, are 20 feet or more higher than the Wainwright Development well, so that the oil prospects appear to warrant at least one test of the Devonian on the high part of the structure. The Wainwright Development well encountered the top of the Devonian at a depth of 2,330 feet and was discontinued at 2,370 feet. It was plugged back to produce from the Wainwright sand, which occurred at 2,232 feet.

In the Wainwright Development well the Wainwright sand was not more than 6 or 7 feet thick and production of oil was less than 10 barrels a day. The small thickness of sand may be significant in relation to the structure, as all sands would be expected to be less thick over or close to the crest of the Devonian knob than at some distance from it. The better production obtained from the Sasko-Wainwright, Edmonton-Wainwright, and Hargal 3B wells could be related to their position away from the high part of the Devonian, with the consequent thicker productive Wainwright sand. The irregularities on the north and northwest flank of the Aykroyd structure, however, are such that definite conclusions are impossible, although it can hardly be a coincidence that the best wells in the Lower Cretaceous beds are down the flanks rather than near the top of the structure. From the drilling of the Wainwell wells in a relatively low Devonian area it is obvious there is a limit to production down

the flanks. Except for Wainwell No. 1 well, which had oil in the top sand of the Lower Cretaceous, and for a large but quickly dissipated flow of gas from Wainwell No. 2 well in the Wainwright sand, the drilling in this area gave negative results. Altogether six wells, comprising Wainwell Nos. 1, 2, 3, and 4, Admiral No. 1, and Beaumont No. 1 wells, were drilled in much the same structural position, with the Admiral well testing the Devonian under conditions that the seismic map indicates are adverse for production. As none of these wells yielded oil from the Wainwright sand it is inferred they are too far down the flank of any erosional high Devonian knob.

The production achieved by such wells as Sasko-Wainwright, l.s. 1, sec. 19, Hargal 3B and Edmonton Wainwright, l.s. 4, sec. 29, and Wainwright Consolidated (Onalta) well, l.s. 8, sec. 20, and their relation to the structure as shown by the seismic map points to the conclusion that section 20 is as favourably located for Lower Cretaceous production as can be chosen in Wainwright area on the basis of present information. Production at the rate of 600 barrels a month is currently being yielded by Hargal 3B well after intermittent production over a period of 18 years amounting to more than 39,000 barrels in an area where this well and Edmonton Wainwright, both in the same legal subdivision, have produced nearly 75,000 barrels of heavy oil.

In conclusion, it appears that the Aykroyd structure offers some prospect of production in the Devonian and that wells at least equal to those now in production are possible in certain areas, particularly in sec. 20, tp. 45, rge. 6.

VALE DOME

This is the largest and best defined erosional knob of Palaeozoic strata, presumably Devonian, known in Wainwright area. (See Figure 2). The minimum closure of the erosional surface is probably to the north or northwest and this is at least 100 feet.

In the Northwest Tit Hills well, l.s. 10, sec. 17, tp. 39, rge. 7, southwest of Czar, light grey dolomitic limestone, also presumably of Devonian age, was encountered at a depth of 3,240 feet or 973 feet below sea-level. Lying on this limestone are 390 feet of beds consisting mostly of white quartz sand with some calcareous material and chert fragments. The age of these beds has always been in doubt, but as previously suggested[1] ..."it is possible that this sandstone to a depth of 3,240 feet, where it is sharply divided from undoubtedly Palaeozoic limestone, is an erosion product deposited on the Palaeozoic floor prior to the deposition of the Lower Cretaceous." Material similar to this is not known above the Devonian in Wainwright area, but is

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1 Hume, G.S.: Oil and Gas in Western Canada; Geol. Surv., Canada, Ec. Geol. Ser. No. 5, p. 222 (1938).

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present in some wells in the vicinity of Lloydminster where, in Altoba No. 2 well, sec. 29, tp. 47, rge. 26, W. 3rd mer., it is 190 feet thick[2]. As this

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2 Hume, G.S., and Hage, C.O.: Geol. Surv., Canada, Mem. 232, p. 14 (1941).

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material, present in the Northwest Tit Hills well, disappears to the north toward Wainwright, the logical place for it to lens out is against the Vale dome, in which case it will form an excellent stratigraphic trap for oil. The seismic information indicates that the top of the Devonian in the Vale dome is at 130 feet below sea-level. This should only be regarded as an approximate depth as the velocity on which it is based was carried from the Admiral well at Wainwright without a closed traverse. The top of the limestone in the Northwest Tit Hills

well is 973 feet below sea-level. Thus the difference, or southerly slope, is approximately 840 feet in 20 miles or at the rate of more than 40 feet to the mile. It is inferred, however, that the slope in the vicinity of the Vale dome, where the material laps up against it, will be locally considerably steeper than this and will decrease away from the dome. The material is composed mostly of clean, fairly coarse quartz sand, and the inference is that it would make an excellent reservoir rock for oil under conditions that are considered to be highly favourable for accumulation.

In regard to production in the Wainwright sand it is assumed that there will be a very considerable dip of all Lower Cretaceous beds away from the Vale dome. The thickness of Lower Cretaceous beds over the Vale dome cannot be predicted, but it is possible it might be less than in the Wainwright Development well where it was only 238 feet. At Northwest Tit Hills well there are 410 feet of Lower Cretaceous strata above the 390 feet of beds that are considered here to be the weathering product lying on the Palaeozoic limestone. Under these conditions it is difficult to predict the rate of dip on the top of the Lower Cretaceous away from the Vale dome, although 10 to 20 feet a mile with the steeper dip nearer the dome is a reasonable assumption. This dip would be quite sufficient to provide a structure favourable for the accumulation of oil in any sand within the Lower Cretaceous.

In regard to the prospects of production in the Devonian on the top of the dome there is very little information on which to base a conclusion. The Northwest Tit Hills well southwest of Czar is reported to have had a show of oil at 3,260 feet in the top of the limestone. This would seem to be of very considerable importance in relation to the prospects of the Devonian in the Vale dome where the top would be expected to be about 800 feet higher. The dip of the limestone beds, however, is unknown, but is assumed to be southwest in the direction of regional dip. This would favour an accumulation of any oil present in these beds toward the Vale dome. The stratigraphic horizon in the Devonian in the top of the Vale dome cannot, however, be predicted in relation to the stratigraphic horizon at the top of the Devonian in the Northwest Tit Hills well, where dolomitic beds at a depth of 3,320 to 3,450 feet show in part good and in part high porosity. There is thus no certainty that this same condition will be found in the Devonian of the Vale dome, but in view of the fact that porosity in the Devonian is so widespread in wells drilled in east-central Alberta the expectation is that similar conditions will occur here. It is, therefore, inferred that the Devonian in the erosional high Vale dome offers a resonably good prospect for oil.

In conclusion, it would seem that the oil prospects of the Vale dome justify testing by: (1) a well into the Devonian on the high part of the structure; (2) a well at some distance down the south flank to test the up dip position of lenticular sands that are here assumed to be the weathering product of the Devonian and rest directly on it in the Northwest Tit Hills well, where they are 390 feet thick; and, (3) a well on the north flank to test the Wainwright sand 120 to 140 feet below the top of the Lower Cretaceous. The deepest of these wells should not exceed 2,800 to 3,000 feet depending on the elevation of the surface.

In making these three tests the Lower Cretaceous should be continuously cored so that the upper sand of the Lower Cretaceous and the Wainwright sand will be penetrated in all three wells.

The testing of the Vale dome is considered important in that production from it would establish the presence of oil on a type of structure that may be quite common in this part of east-central Alberta.

AVAILABILITY OF SEISMIC DATA

All seismic records made in the survey of Wainwright area are available for examination and study at the offices of the Geological Survey, Ottawa.

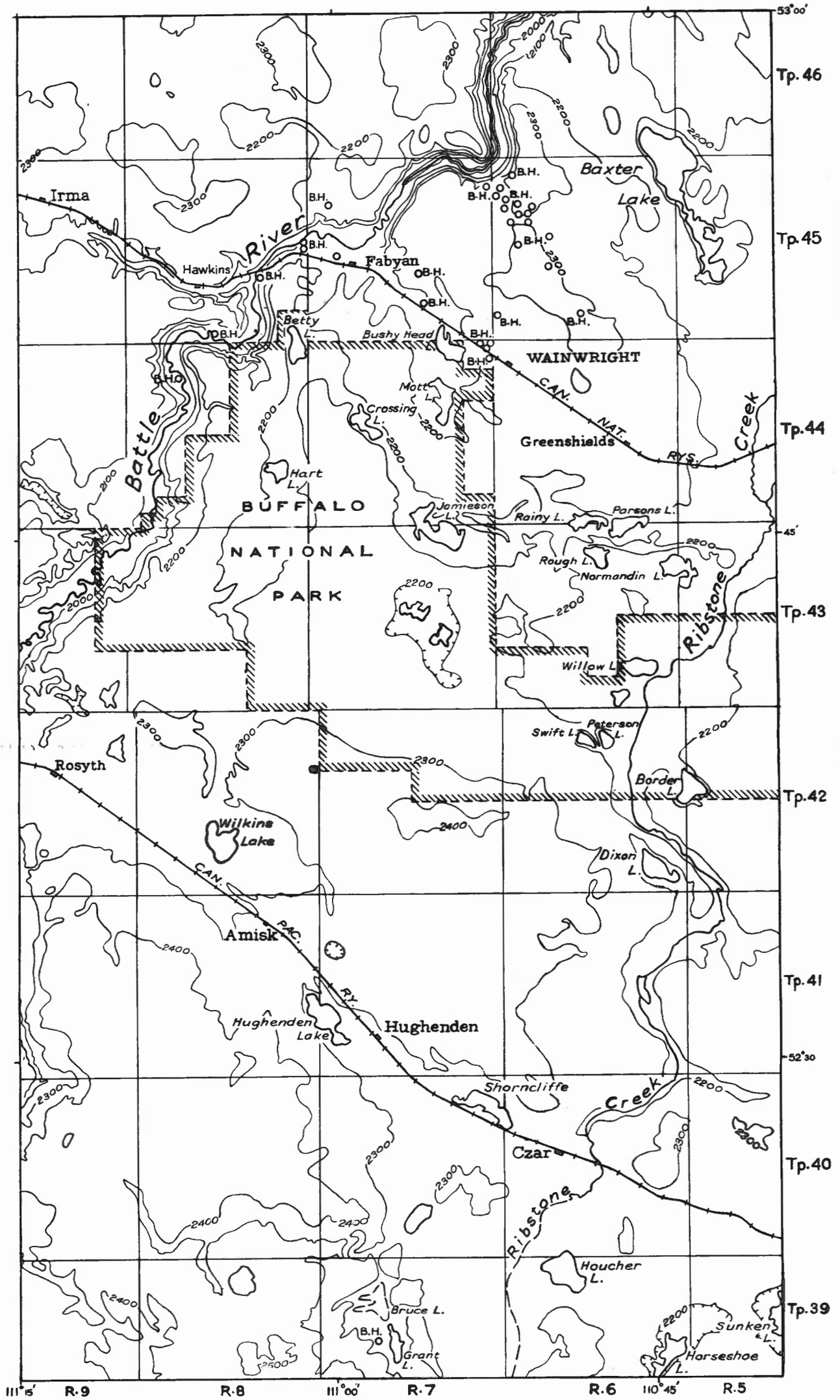

Figure 1. Index map showing BUFFALO NATIONAL PARK and adjoining areas, West of Fourth Meridian, Alberta.

Scale:- 1 inch to 4 miles

Geological Survey, Canada

Figure 2. MOTT LAKE and AYKROYD STRUCTURES showing subsurface structural contours on top of the Devonian, as indicated by Heiland Seismic Survey, 1943.

Tp. 45

Tp. 44

Battle River

Fabyan

CAN. NAT. RYS.

Aykroyd Structure

WAINWRIGHT

Park boundary

Mott Lake Structure

BUFFALO NATIONAL PARK

Park boundary

N.R.

INDEX TO WELLS

1. Admiral No. 1
2. Wainwell No.1
3. Wainwell No. 2
4. Wainwell No. 3
5. Wainwell No. 4
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22. Hargal (British Petroleums) No. 1
23. Hargal (British Petroleums) No. 2
24. Hargal (British Petroleums) No. 4
25. Wainright Dome

Structural contour interval, 20 feet —60—

Elevations referred to mean sea level

Shot point, elevation of limestone surface •-170

Shot point, no record N.R.

Producing oil well ●12

All other wells o13

Scale:- 1 inch to 1 mile

Geological Survey, Canada

R.7 R.6

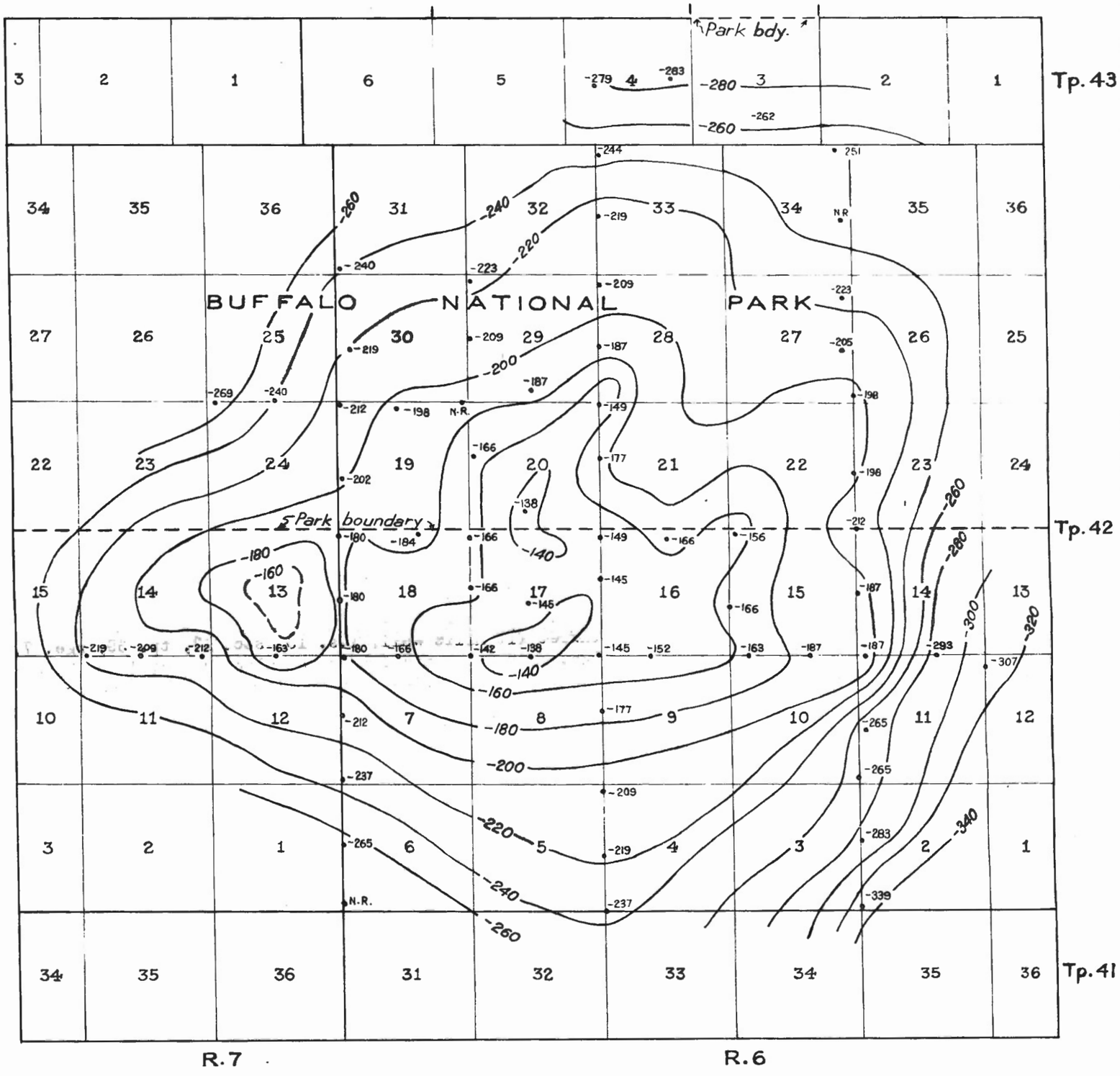

Figure 3. VALE DOME showing subsurface structural contours on top of the Devonian, as indicated by Heiland Seismic Survey, 1943.

Structural contour interval, 20 feet ——-160——

Elevations referred to mean sea level

Shot point, elevation of limestone surface ---•-209

Shot point, no record ---- ---------• N.R.

Scale:- 1 inch to 1 mile